Super-K status report

1/29/02

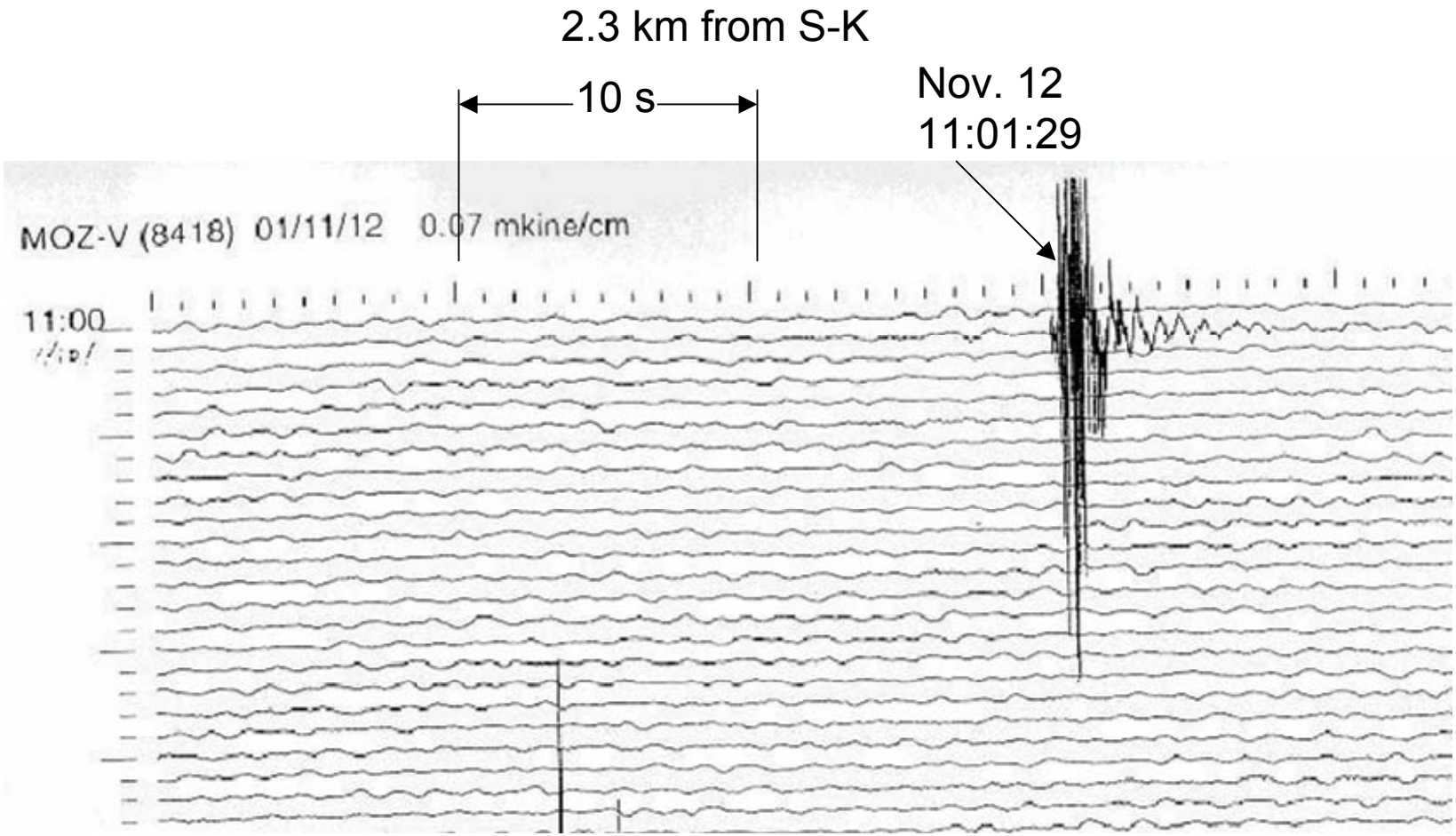
HEPAP meeting

H. Sobel
U.C. Irvine

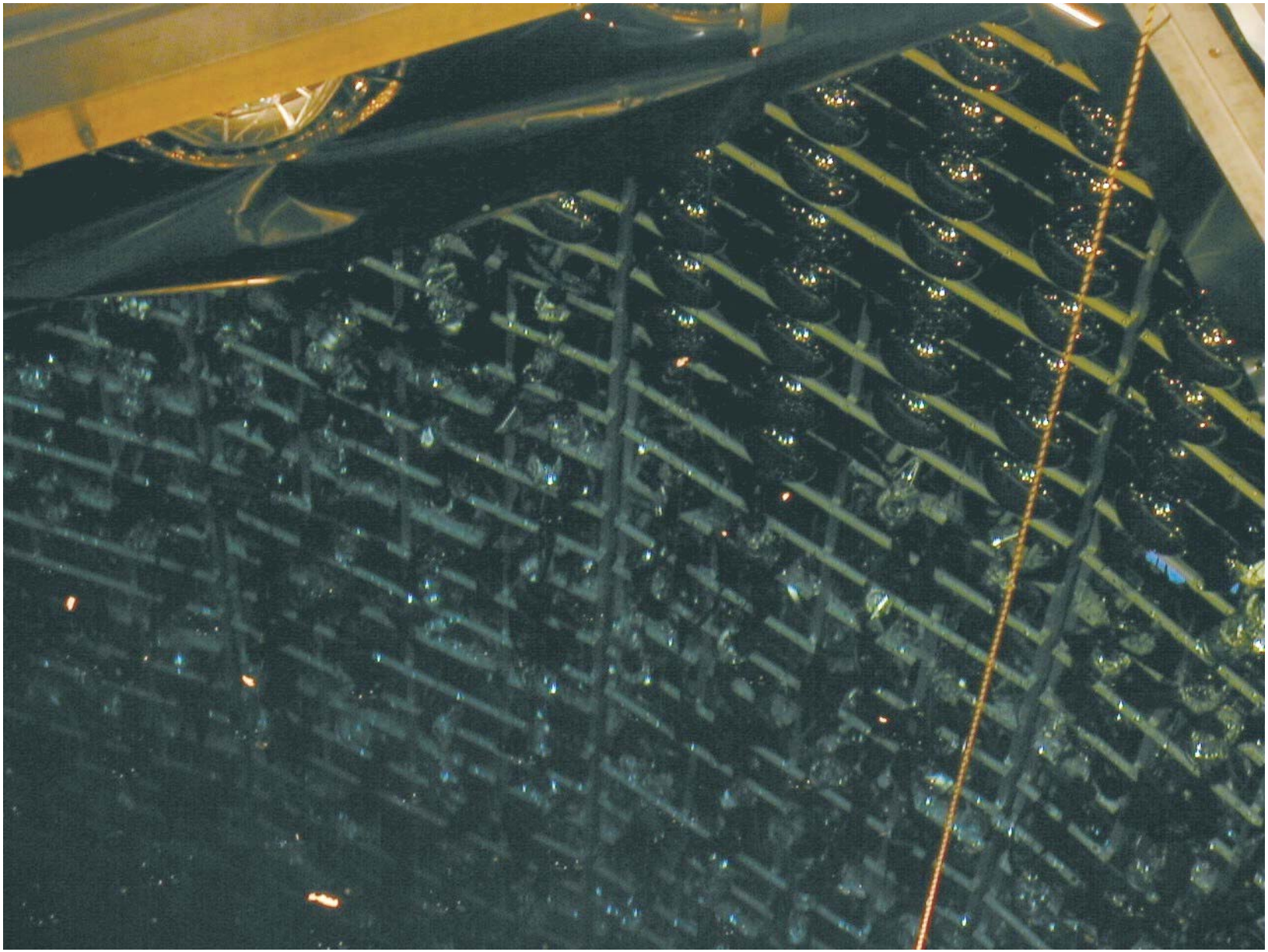
Accident sequence

- We were in the process of refilling the detector after have drained it for the first maintenance since the initial fill in 1996.
- During this maintenance, we replaced about 250 inner detector 20” tubes and 280 8” outer detector tubes.
- On Nov. 12 we were about 7 meters from completion.

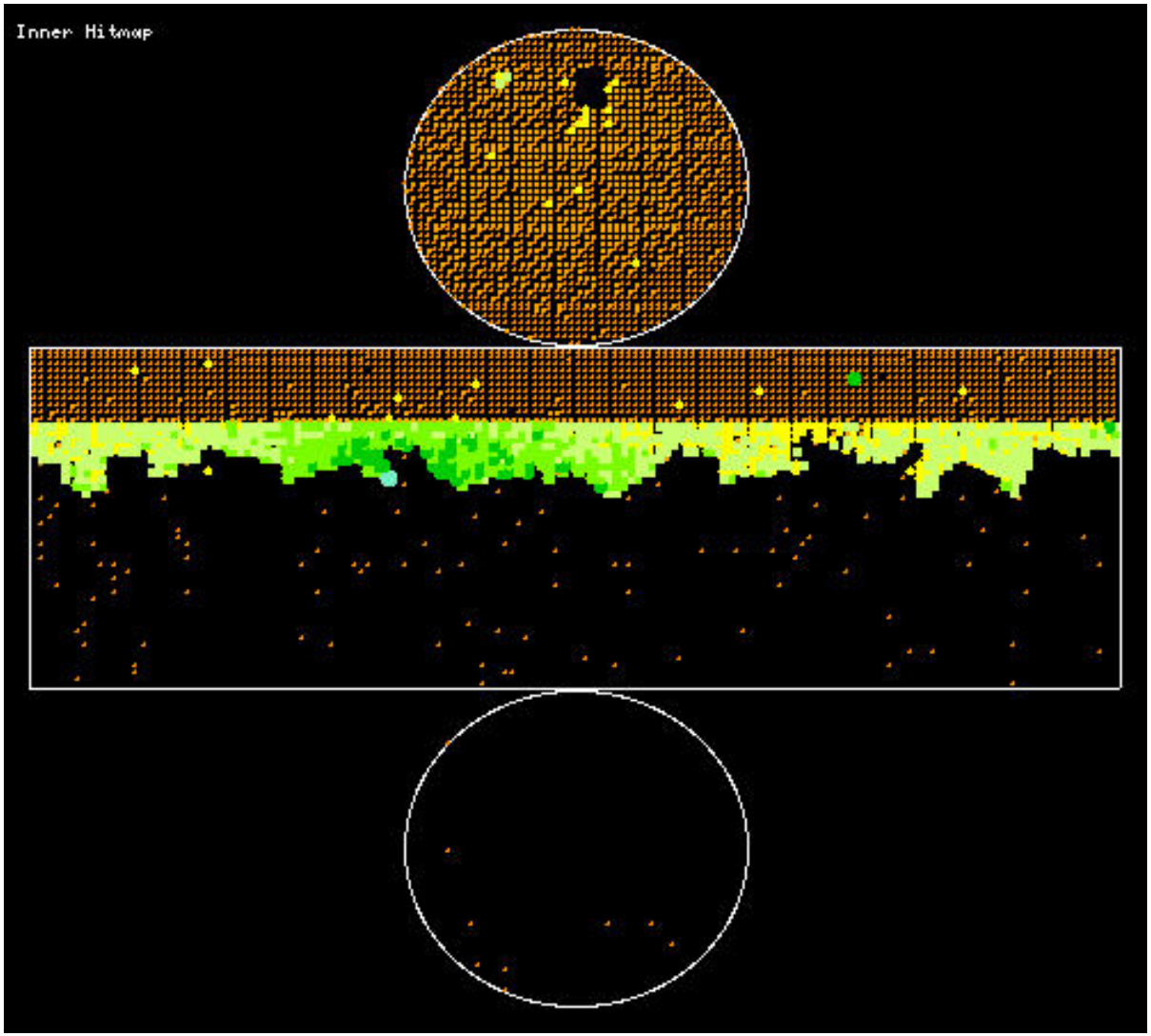
Seismic recording



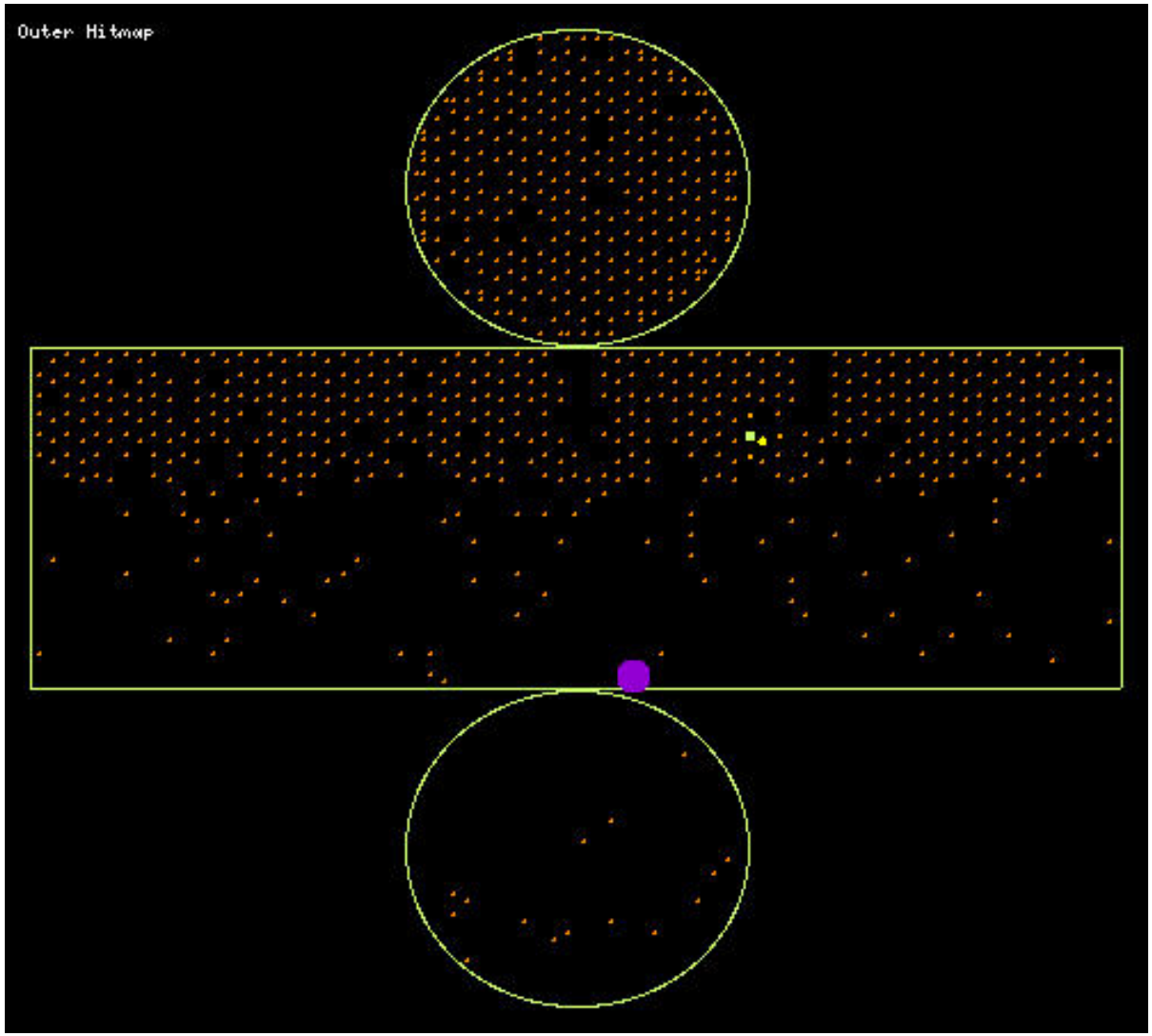
Damage



ID damage



OD damage



University of Tokyo committee

- M. Yoshimura (Chair, Director of ICRR)
- K. Nakamura (Director of KEK PS)
- A. Suzuki (Prof. Tohoku Univ.)
- T. Sasajima (Shipbuilders' Assoc. of Japan)
- Y. Suzuki (Prof. Univ. of Tokyo)
- Y. Totsuka (Prof. Univ. Of Tokyo, S-K spokesman)
- T. Fujiwara (Nagoya Univ. Engineering)
- T. Kajita (Prof. Univ. of Tokyo)
- H. Sobel (UCI)
- Y. Matsumoto (Nagoya Univ. Engineering)
- H. Sugawara (Director of KEK)
- A. Koma (Vice Pres. Univ. of Tokyo)

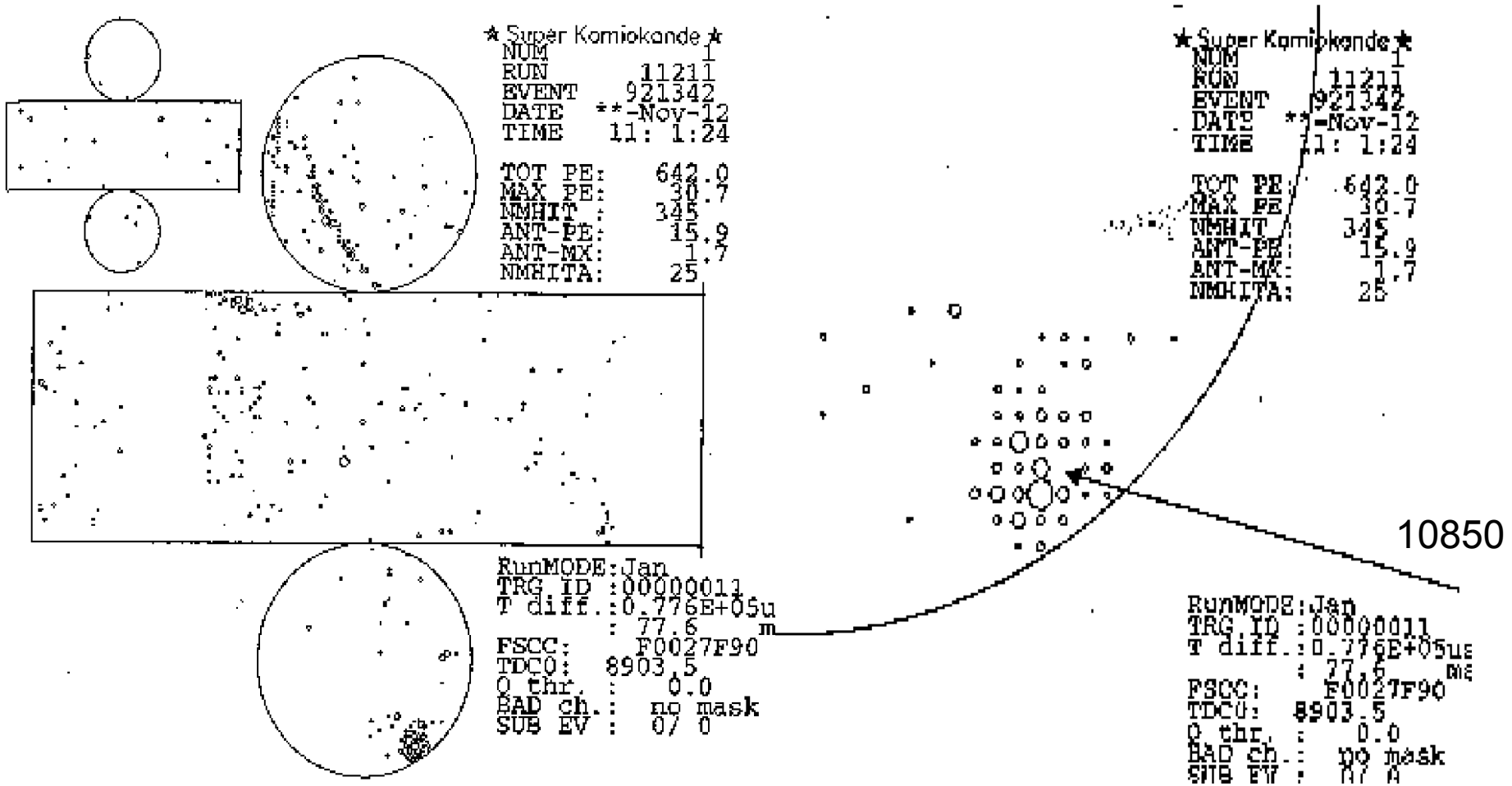
Committee charge

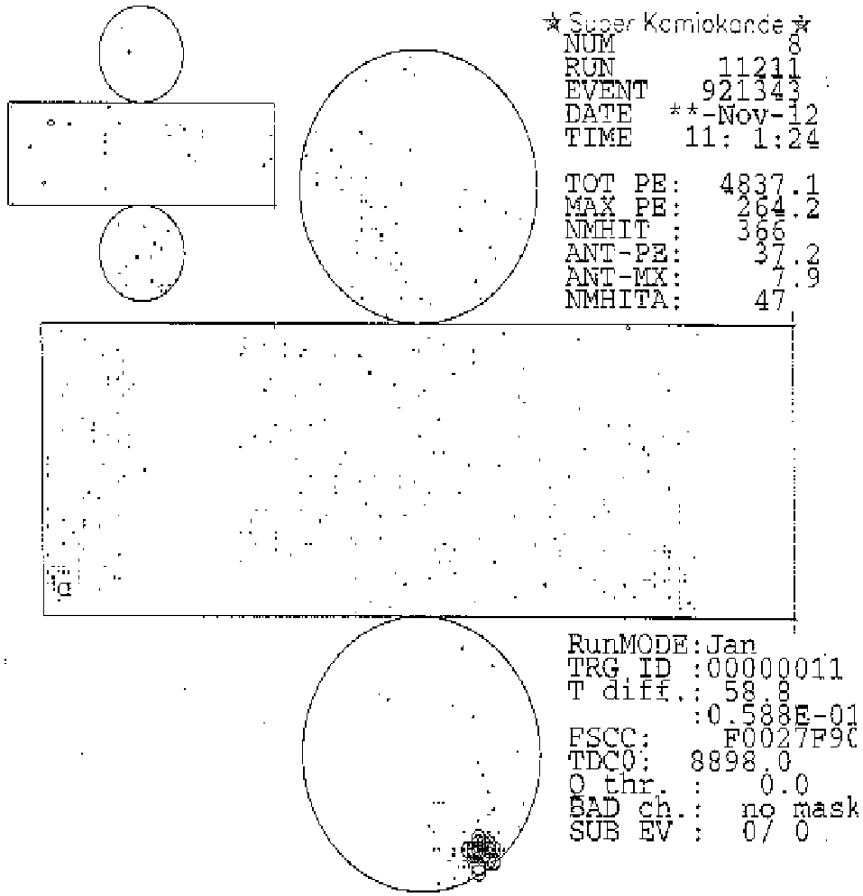
- Damage to detector
- Cause and mechanism
  - Identify first PMT
  - Establish possible mechanisms
  - Examination of remaining tubes
  - Numerical simulation
  - Experimental simulation
- Countermeasures
  - Proof that detector can operate safely

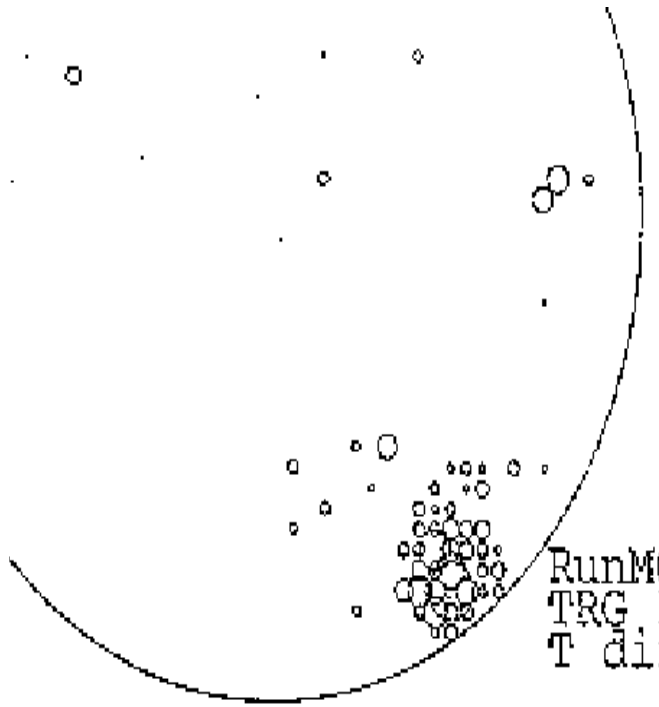
Detector damage

Damaged PMT's	6777 (out of 11146 20" tubes 1149 (out of 1885 8" tubes)
Electronics damage	none
High voltage damage	negligible
Wavelength shifting plates	700 (out of 1885 damaged)
Plastic, Tyvek sheeting	Needs total replacement
Cables	Still undetermined
Tube frames/housings	Extensive damage
Small water leak	4.2 tons/hr
Damage to detector structure	none

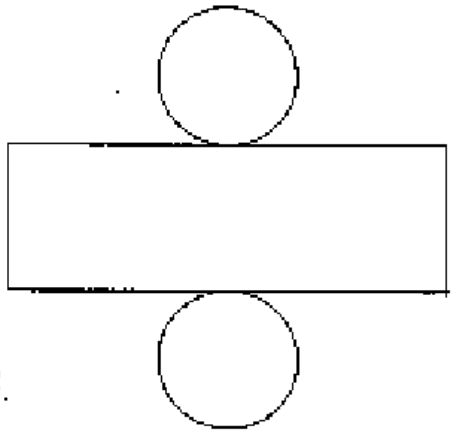
Event record

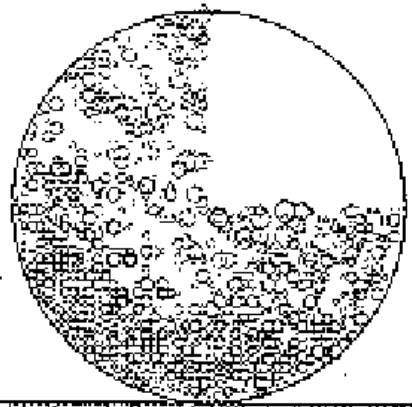






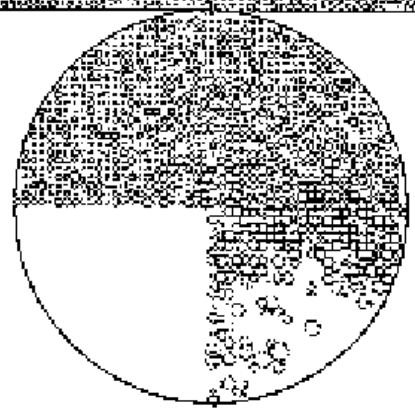
RunMODE:Jan
TRG ID :00000011
T diff.:0.776E+05
: 77.6
FSCC: F0027F9C
TDC0: 8903.5
Q thr. : 0.0
BAD ch.: no mask
SUB EV : 0/ 0





★ Super Kamiokande ★
NUM 7358
RUN 11211
EVENT 921405
DATE **-Nov-12
TIME 11: 1:24

TOT PE: 135694.3
MAX PE: 205.9
NMHIT : 5601
ANT-PE: 0.0
ANT-MX: 0.0
NMHITA: 0



RunMODE:Jan
TRG ID :00001000
T diff.: 14.0
:0.140E-01
FSCC: F002509F
TDC0: 14910.0
Q thr. : 0.0
BAD ch.: no mask
SUB EV : 0/ 0

Isolation of initial PMT

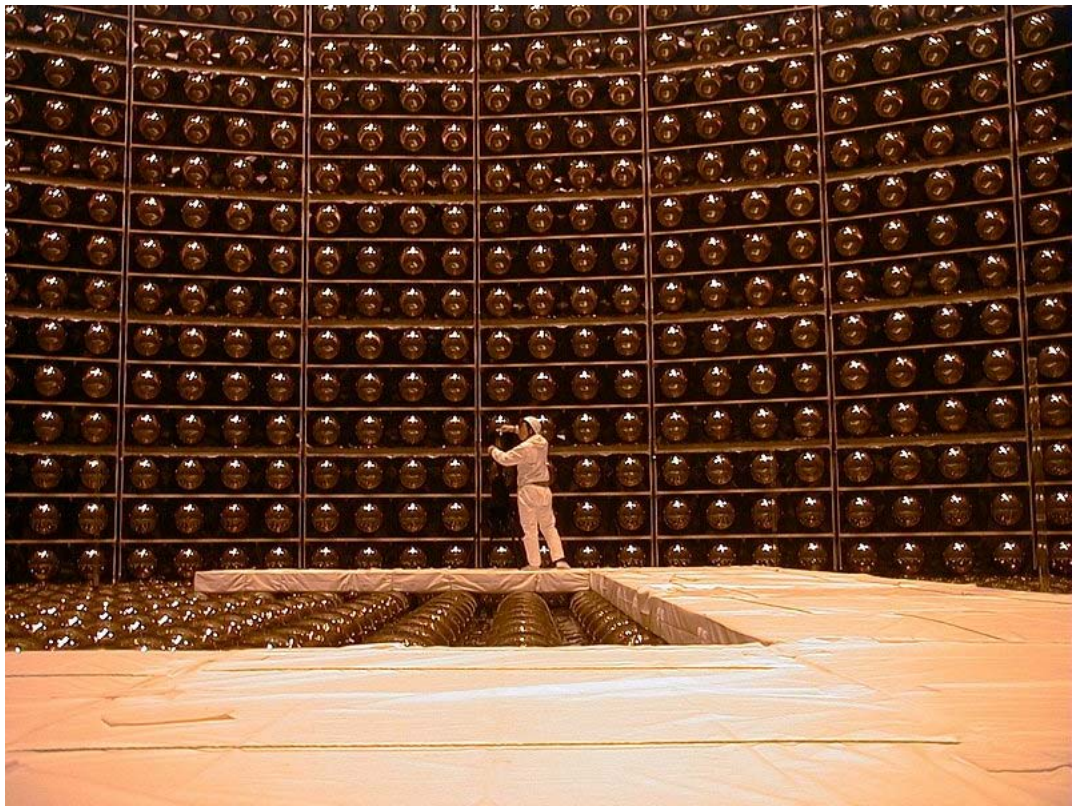
- Using this and other information we have narrowed the field down to two tubes…one which was not replaced during the maintenance and one which was.

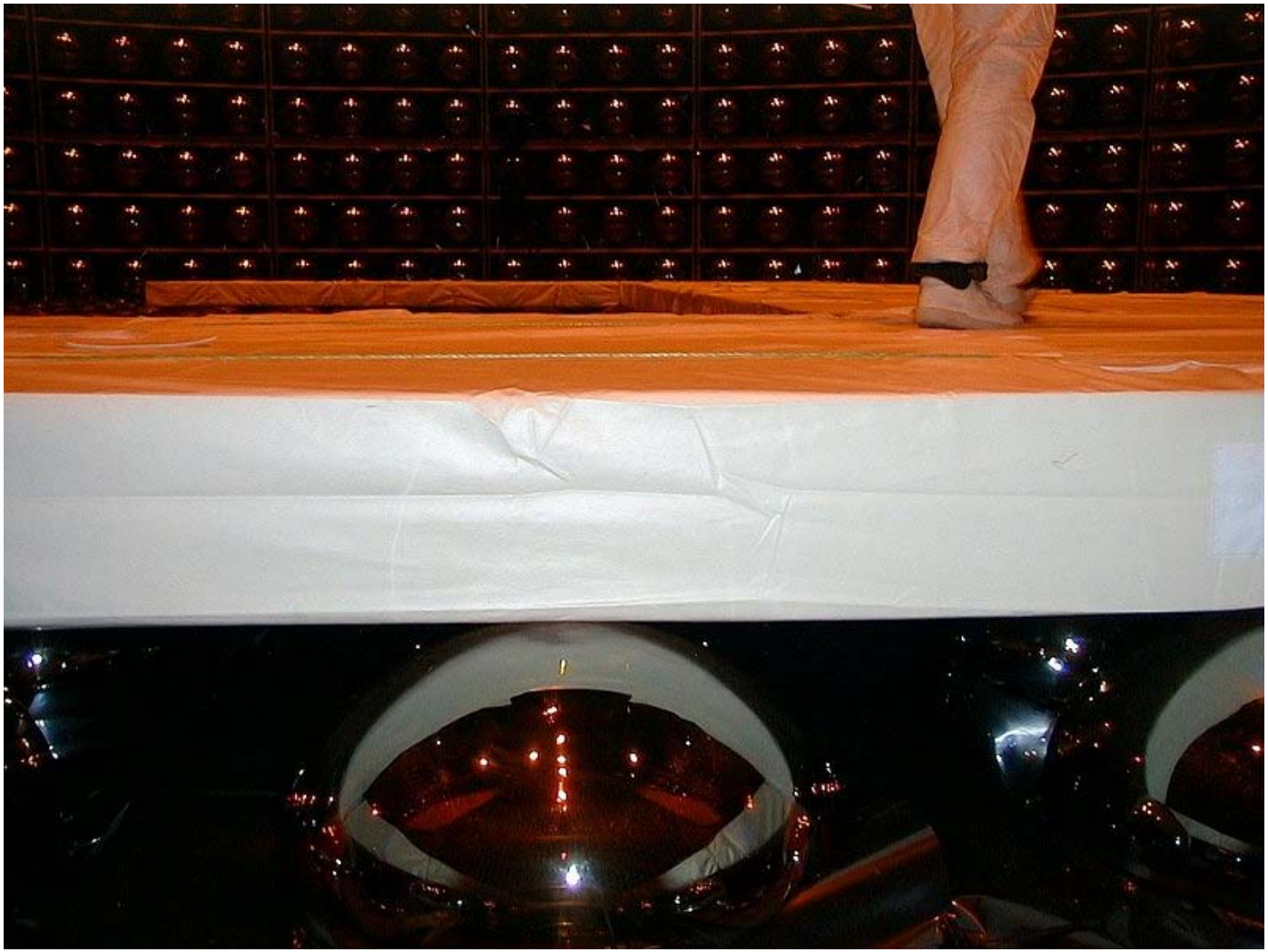
So, why did it break?

Tube tests

- Tested tubes that were removed during summer work
  - Chemical composition
  - Mechanical specs
  - X-ray analysis…look for crystallization
  - Temperature cycling 5-25^{o} C
  - Pressure cycling
- No deviation from expected values

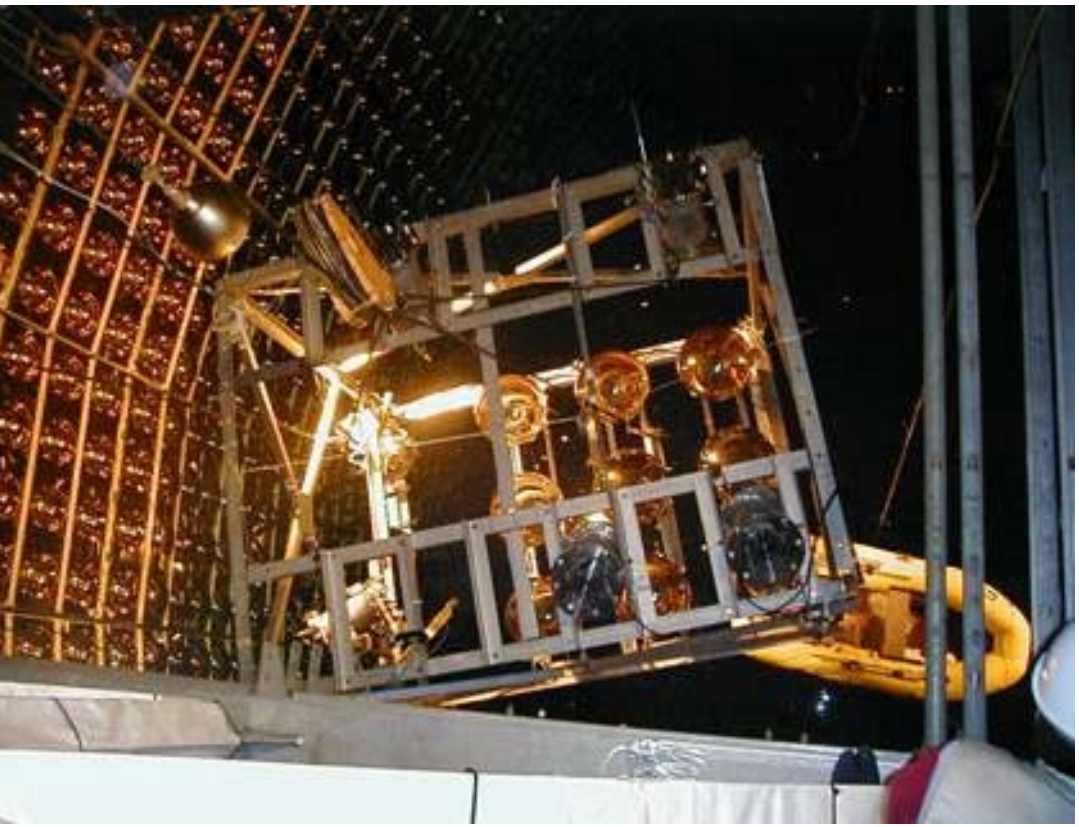
PMT replacement

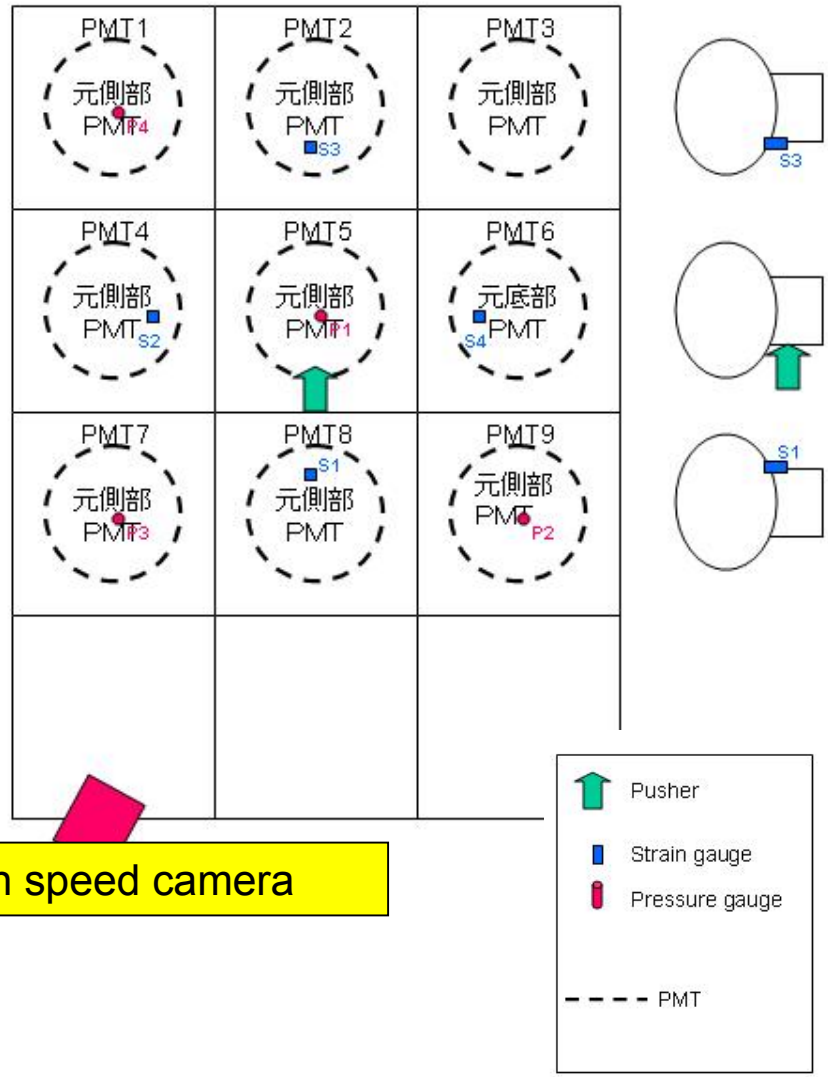




Tube installation on bottom

Implosion simulation

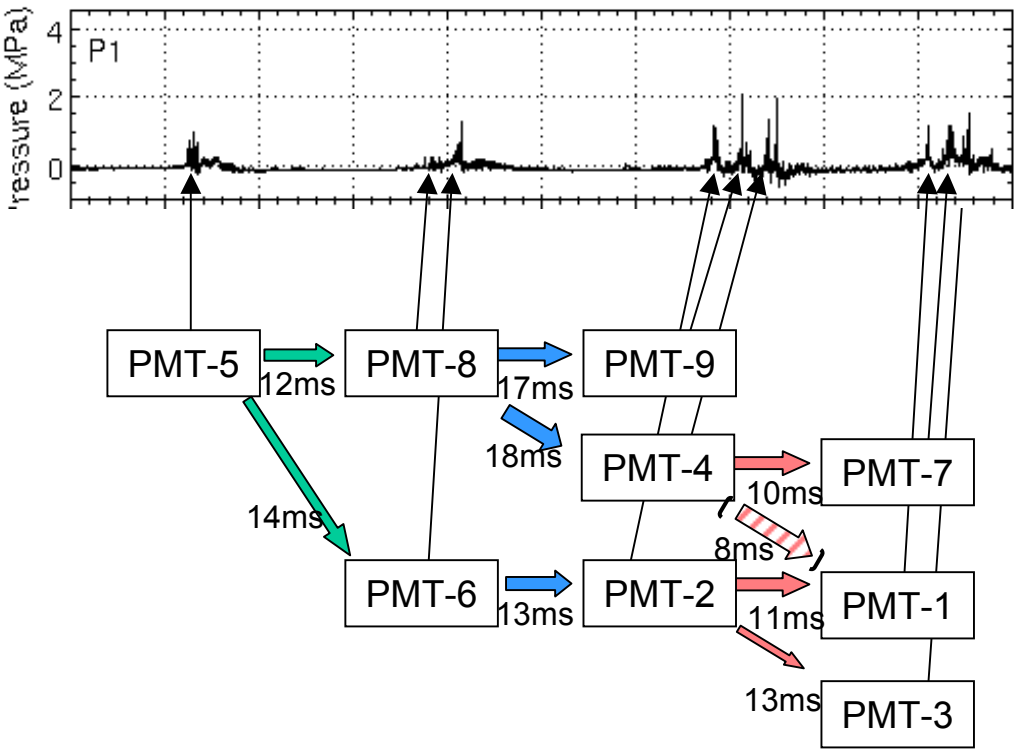


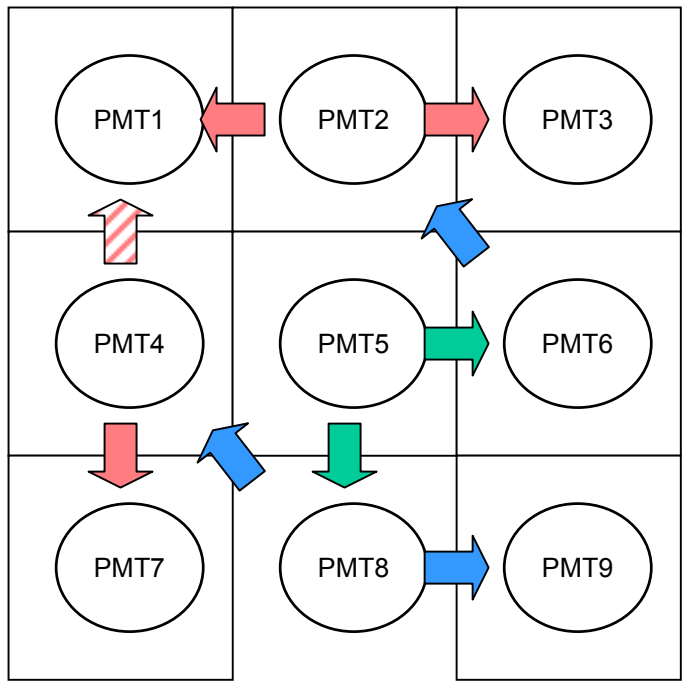


High speed camera

Implosion simulations

Implosion data





Observed pressure pulse at 0.45m from tube center is about 5.6 Mpa.
Idealized simulation predicts about 13 Mpa.

PMT protection

- Several designs tested based on numerical simulation and experimental results.
- All include encasing each PMT.
- Perforated acrylic dome flanged to various base materials.
- Several successful designs tested at 30 meters.
- Still to be tested (this week) at 40 meters.

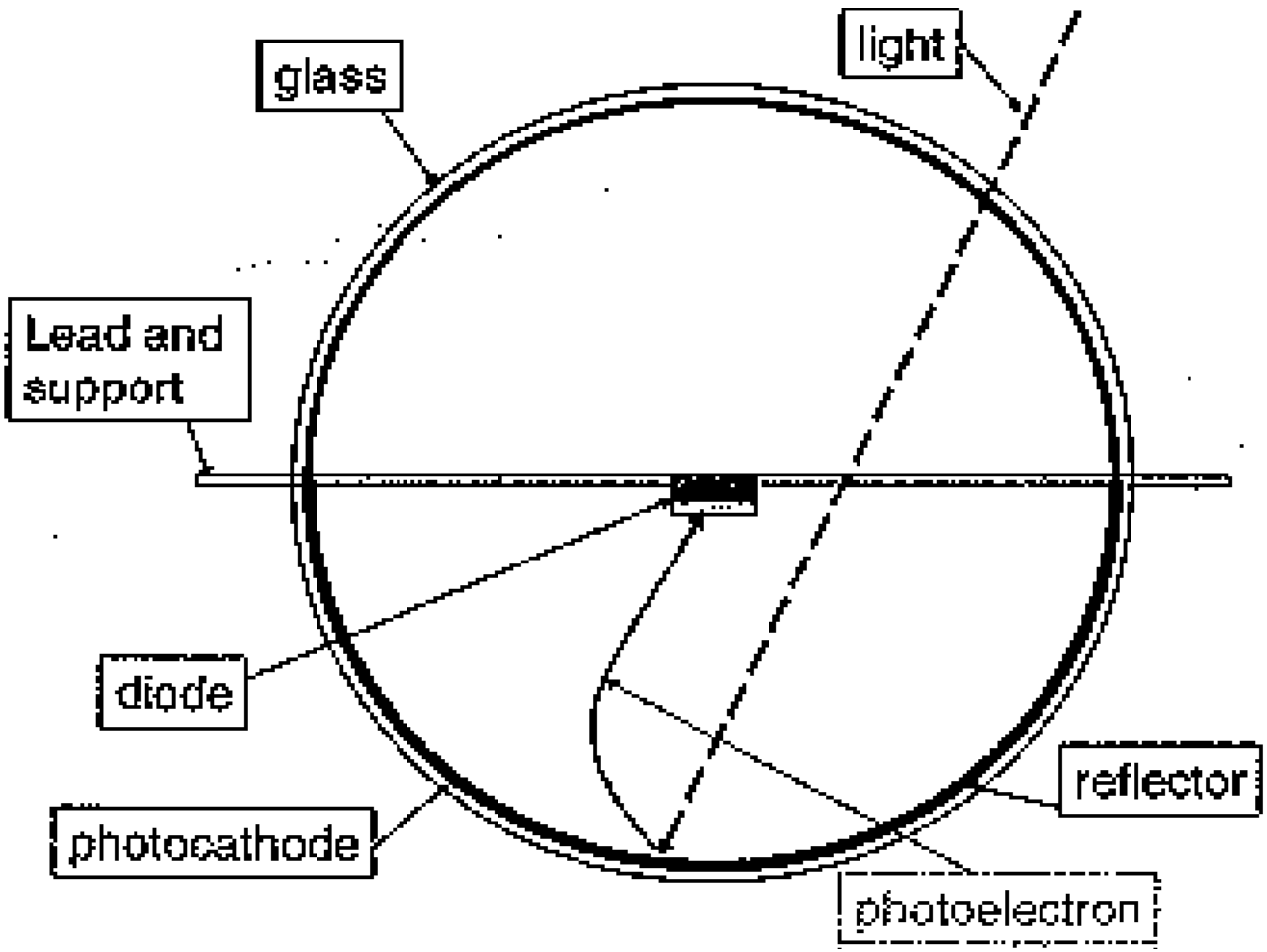
Test at 30 meters depth

10 mm acrylic, 5 mm fiberglass

Reconstruction plans

- Since full replacement of ID tubes will take about 4 years for Hamamatsu to manufacture…
- Use remaining ID tubes plus spares on hand to reconstruct ID with ½ PMT density.
  - Other options are being investigated…e.g. new tube design.
- Replace OD immediately to full density.
- Majority of physics topics can go forward unchanged.

Possible new tube design

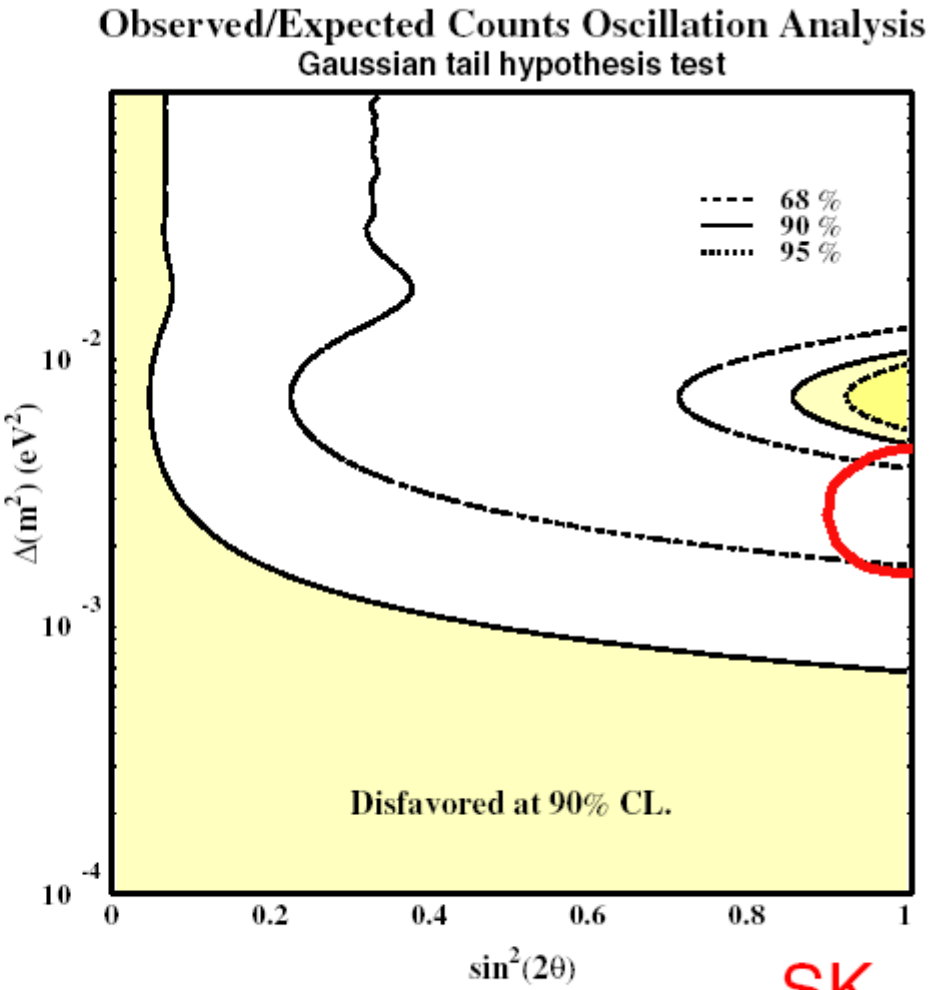


K2K experiment status

5.6 x 10^{19} POT delivered,
through July 2001

Event Summary:

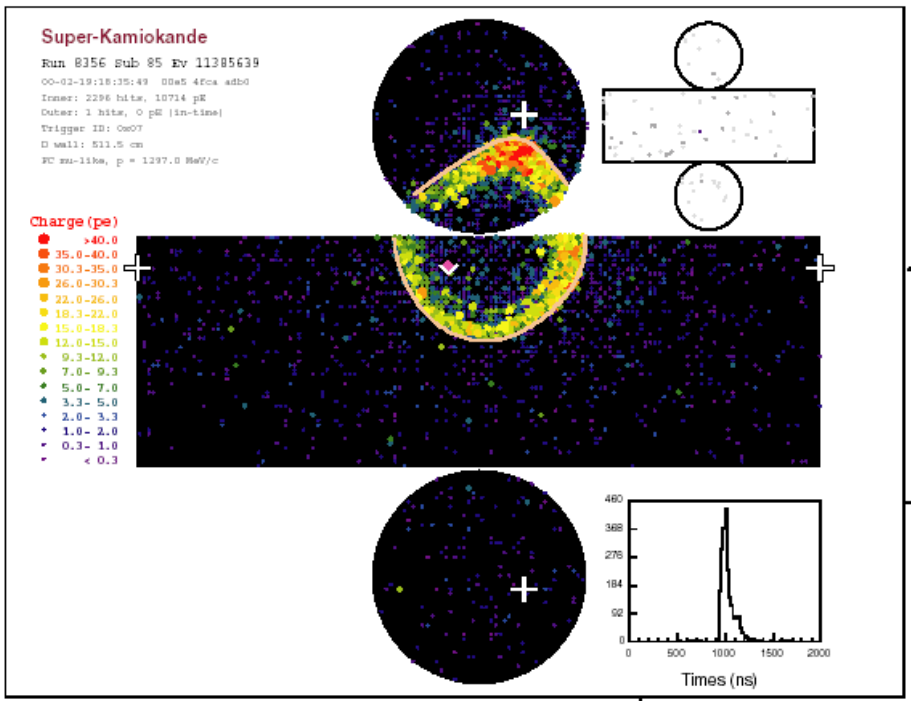
	detected	no osc	3x10^{-3}
FC	56	80.6±8.0	52.0
1-ring μ	30	43.6±6.9	24.2
1-ring e	2	4.4±1.7	3.7
multiring	24	31.9±5.3	24.1
OD events	43		
contained	21		
entering	10		
exiting	12		



SK best-fit

Above based only on total rate
Expect 3.3 to 4.4 σ
after 10^{20} POT

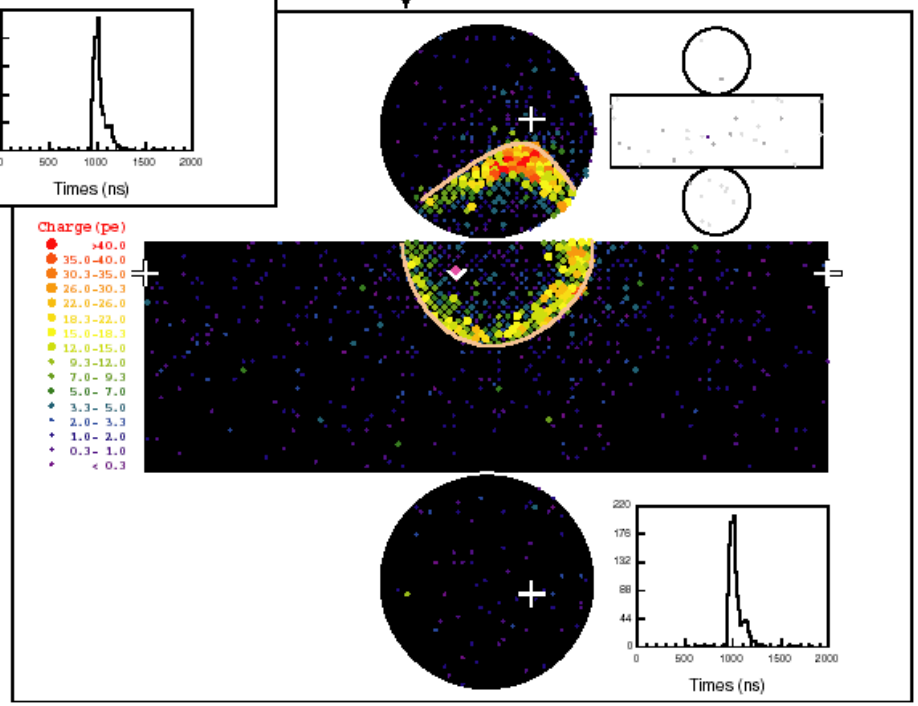
K2K event



K2K Event:
1.3 GeV single-ring μ

as recorded

50% of PMTs masked off

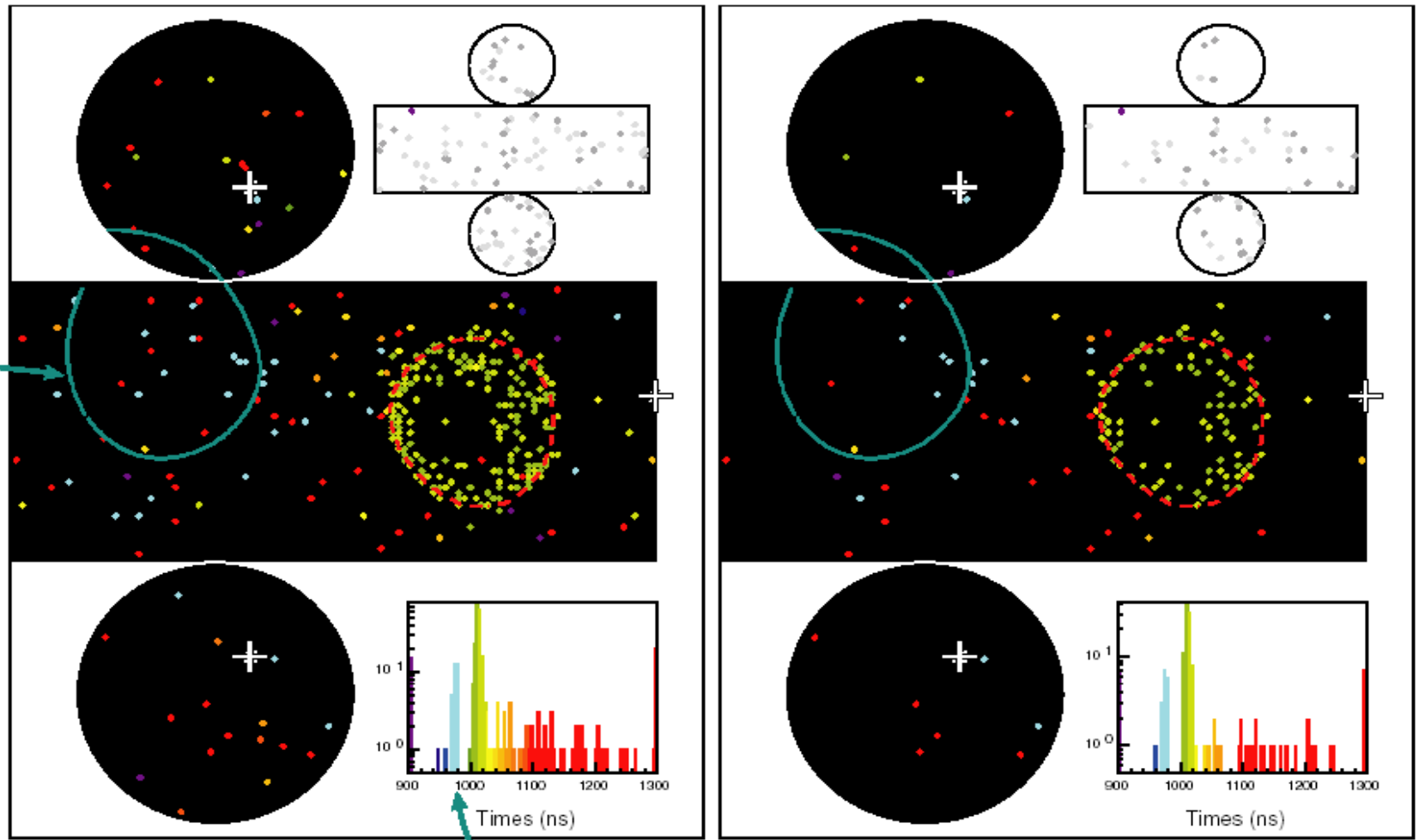


Momentum and angle from beam direction should be measurable with negligible loss of accuracy

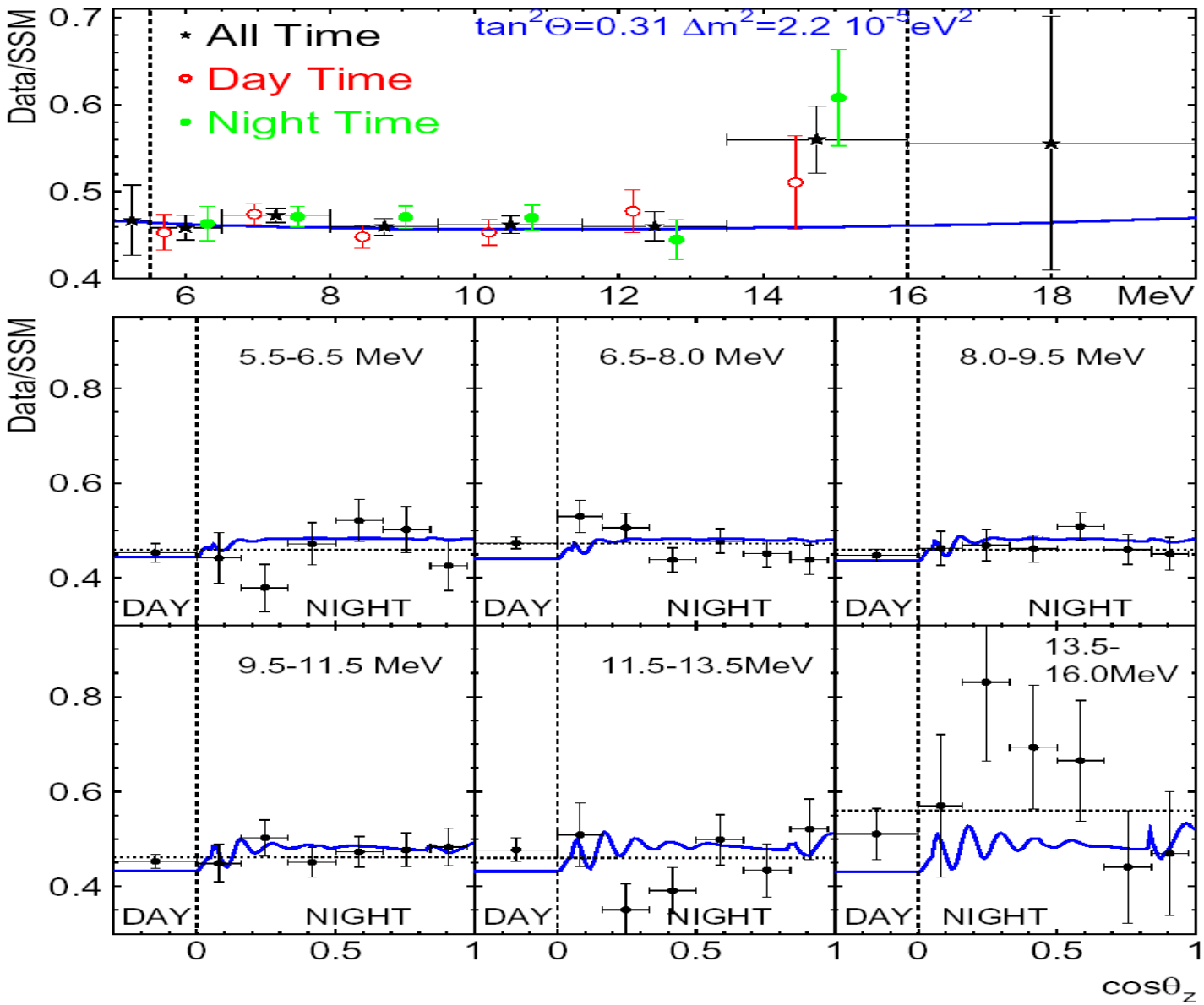
νK^+ proton decay

Proton Decay to $K^+ \nu$: $K^+ \rightarrow \mu\nu$ with prompt tag from $^{16}N^* \rightarrow {}^{16}N + \gamma$

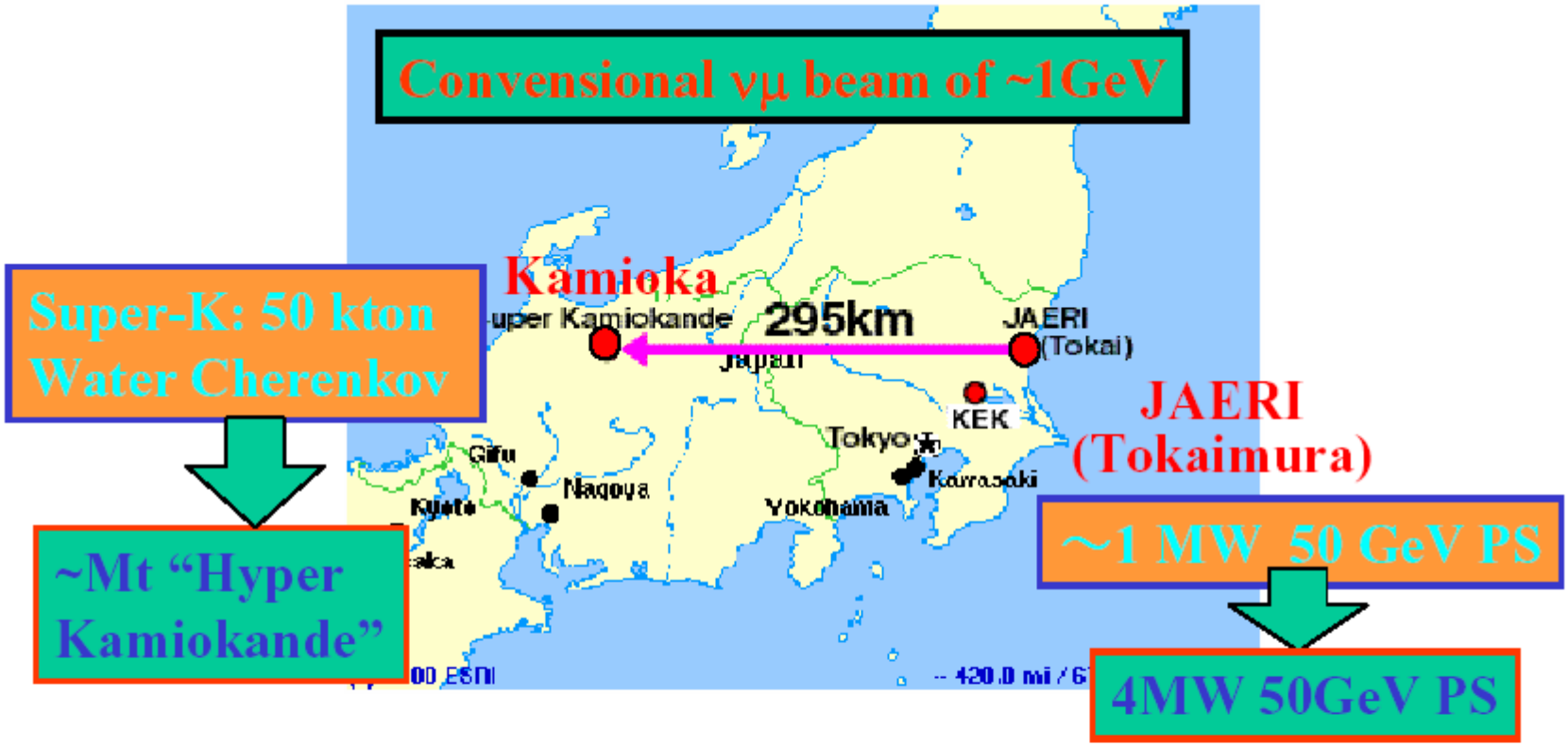
8 or more hits in 12 ns sliding window preceding muon (K+ is below Cherenkov threshold)



Day/Night


All Time
Day Time
Night Time
tan²Θ=0.31 Δm²=2.2 10⁻⁵eV²
Data/SSM
MeV
5.5-6.5 MeV
6.5-8.0 MeV
8.0-9.5 MeV
9.5-11.5 MeV
11.5-13.5MeV
13.5-16.0MeV
DAY
NIGHT
cosθz

JHF to Kamioka overview



1st Phase

- $\nu_\mu \rightarrow \nu_x$ disappearance
- $\nu_\mu \rightarrow \nu_e$ appearance
- NC measurement

2nd Phase

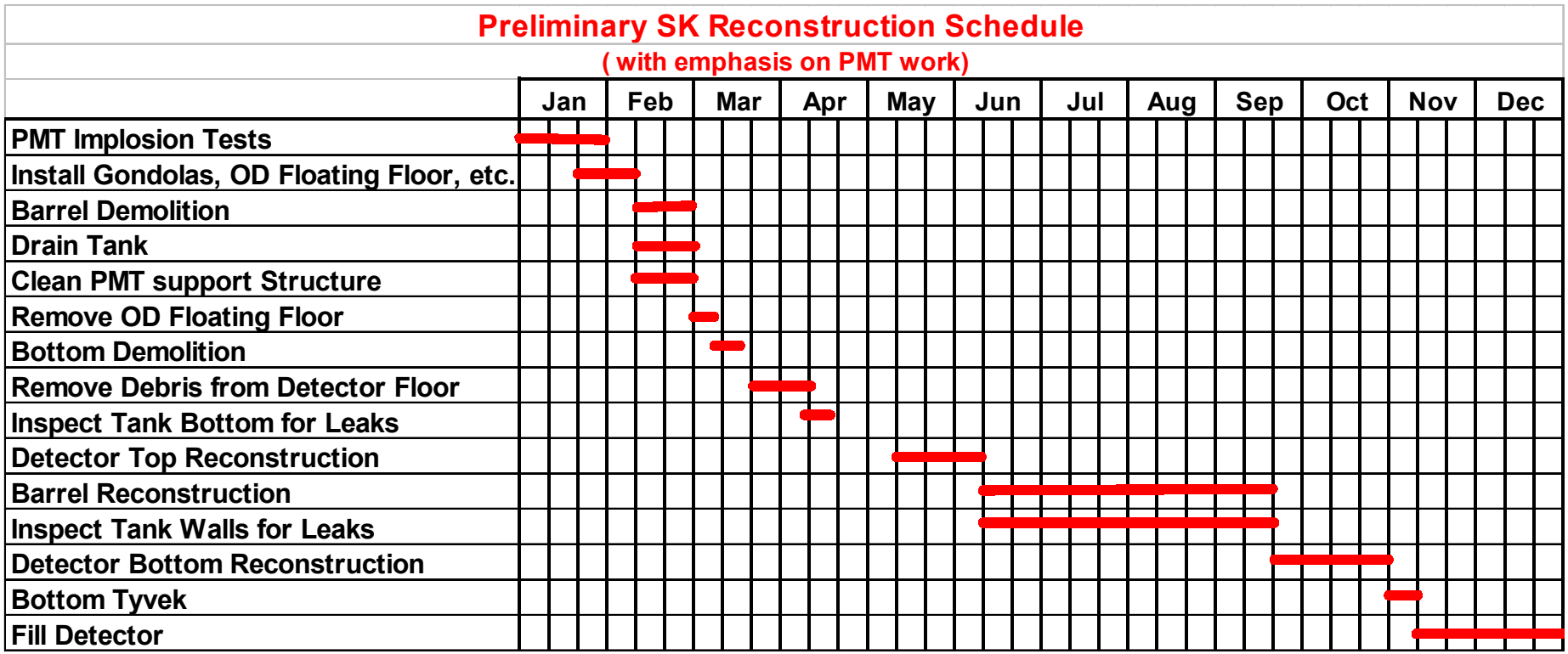
- CPV
- proton decay

Begin decay pipe construction 2002
Data taking April 2007

JHF summary

- **JHF-Kamioka Neutrino project**
  - ✓ **~MW 50GeV** PS @ JHF
  - ✓ **Super-Kamiokande**@ 295km as far detector
  - ✓ Low energy(~1GeV) conventional **ν_μ beam tuned at osc. max.**
  - ✓ Energy reconstruction by using **QE**
  - ✓ **Narrow OAB** to reduce background and syst. err.
  - ✓ NBB to study neutrino interaction for syst. error reduction
- **Physics sensitivity in first phase**
  - ✓ **$\sin^2 2\theta_{13} \sim 0.003$ (90% CL)**
  - ✓ $\delta \sin^2 2\theta_{23} \sim 0.01$
  - ✓ $\delta \Delta m_{23}^2 < 1 \times 10^{-4} \mathrm{eV}^2$
  - ✓ ν_s existence can be tested.
- **2nd phase 4MW PS & Mt "Hyper-Kamiokande" detector**
  - → Sensitive to CPV of $\delta > 10\sim20^\circ$ with LMA solution
  - → Proton decay 3σ discovery up to $\tau \sim 1\times10^{35}(>3\times10^{34})$yr for $e\pi^0(\nu K)$ mode

Schedule


Preliminary SK Reconstruction Schedule
(with emphasis on PMT work)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
PMT Implosion Tests
Install Gondolas, OD Floating Floor, etc.
Barrel Demolition
Drain Tank
Clean PMT support Structure
Remove OD Floating Floor
Bottom Demolition
Remove Debris from Detector Floor
Inspect Tank Bottom for Leaks
Detector Top Reconstruction
Barrel Reconstruction
Inspect Tank Walls for Leaks
Detector Bottom Reconstruction
Bottom Tyvek
Fill Detector